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Short note
Sexual dimorphism in *Patagonotothen sima* (Richardson, 1844)

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Introduction

In Argentina, the Nototheniidae is represented by about 20 species, which mostly live in coastal waters of the continental shelf and slope. A few species inhabit inshore waters along the coasts of Patagonia and the Fueguian and Falkland (Malvinas) archipelagos and even reach rocky intertidal zones (Norman 1937, Hart 1946). *Patagonotothen sima* (Richardson 1844) is distributed in the Atlantic from the San Matías Gulf (around 42°S) to the Beagle Channel (54°50'S), inhabiting shallow waters including the intertidal zones. During faunal surveys in the rocky intertidal zone in Puerto Deseado, Santa Cruz (by A. Gosztonyi), it was noted that males of *P. sima*, one of the most common fish species in that habitat, appeared to have a higher second dorsal fin than the females.

Materials and methods

Thirty males (48.7–116.5 mm SL, $\bar{x}$ = 80.8, s e = 3.2) and 32 females (50.7–113.7 mm SL, $\bar{x}$ = 74.2, s e = 3.5) were analysed. The specimens were captured in inshore waters of Chubut Province (Puerto Lobos in San Matías Gulf, Valdés Peninsula, Nuevo Gulf and Puerto Rawson), and in the rocky intertidal zone of Puerto Deseado, Santa Cruz Province (47°45'S, 65°55'W). Collections were made using shore seines (in Península Valdés), bottom trawls (in Puerto Rawson), or by hand (Puerto Deseado). All the specimens are stored in the Centro Nacional Patagónico Ichthyology Collection in Puerto Madryn, and catalogued as follows:- Females: CNPICT 1968/1/1–1968/1/12; 1969/1/1–1969/1/3; 1988/1/1; 1988/2/1; 1988/2/2; 1988/3/1–1988/3/3; 1989/1/1; 1992/1/1; 1992/1/2; 1997/1/1–1997/1/8. Males: CNPICT 1968/1/5/13–1968/1/20; 1969/1/4–1969/1/11; 1982/1/1; 1988/2/3; 1988/3/1; 1997/1/9–1997/1/20.

Nineteen point to point measurements were taken with a digital calliper to the nearest 0.01 mm on the left side of each specimen (Fig. 1): total length (TL); standard length (SL); predorsal length 1 (PRD1); predorsal length 2 (PRD2); head length (HL); prepelvic length (PRV); preanal length (PRAN); eye length (EL); interorbital width (INTO); pectoral fin length (PEC); pectoral fin base (PB); pelvic fin length (PL); body depth (BD); first dorsal fin base (D1B); first dorsal fin height (D1H); second dorsal fin base (D2B); second dorsal fin height (D2H); anal fin base (ANB); anal fin height (ANH). The sex was determined by macroscopic observation of gonads.

Female and male intervals of $\bar{x} \pm$ s d of the soft-dorsal fin height relative to the standard length (D2H/SL) were established. To resolve the classification of specimens within the overlapping tails of the distribution of D2H/SL frequencies, log-transformed data were analysed using multivariate discriminant analyses. To obtain a classification function involving a minimal number of characters, Stepwise Discriminant Analysis (BMDP7M: Dixon 1992) was applied. BMDP 7M was used for selecting the morphometric characters with highest discriminant power and the final discriminant function was computed applying the nonparametric Fisher's Linear Discriminant Function (Mardia & Kent 1979; software AMDIS ver. 240893 by A. Aubone). With the variables selected in BMDP7M, the final discriminant function was computed over male and female subsamples of 20 specimens of equivalent size to avoid size effects in the analysis. The remaining specimens (10 males and 12 females) were used to test the resulting discriminant function. The subsamples were selected considering the standard length as a good estimator for size. Two group Kolmogorov-Smirnov test (Conover 1980; STATISTICA) was applied to test the equality of the distribution of the standard lengths on both female and male subsamples.

Results

The two group Kolmogorov-Smirnov test showed that the SL of both female and male subsamples had very similar distributions ($P > 0.1$; males: $\bar{x}$ = 81.14, s d = 18.09, n = 20; females: $\bar{x}$ = 83.8, s d = 18.49, n = 20). Thus, the equivalence of size distribution between the subsamples was assumed and no size interference was expected.

Female and male intervals $\bar{x} \pm$ s d and histograms of D2H/SL proportions are shown in Table I and Fig. 2. The intervals are not overlapping. Thus, by evaluating the D2H/SL proportion, the sex of most specimens (85%) could be assessed. Males ($\bar{x}$ = 0.1528; n = 30) have on the average a 27.44% higher soft-dorsal fin than females ($\bar{x}$ = 0.1199; n = 32). Despite these different intervals, there is an overlapping zone in the frequency distributions of males and females D2H/SL proportions (histograms). To improve the classification in this zone, multivariate discriminant analyses were carried out.

A Stepwise Discriminant Analysis classified the specimens using three characters: soft-dorsal fin height (D2H), preanal length (PRAN) and pectoral fin length (PEC). Fisher's Linear Discriminant Function of the three variables satisfactorily

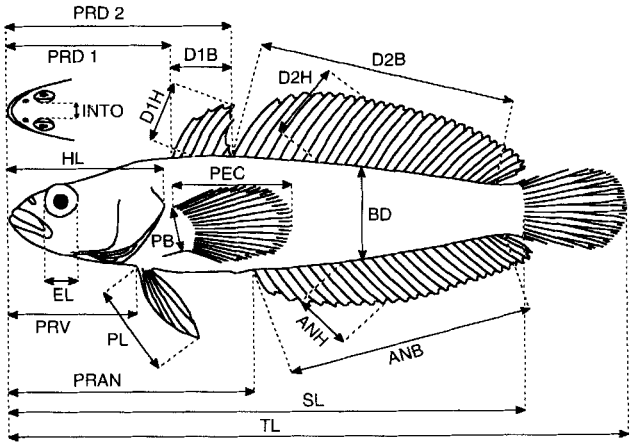

Fig. 1. Morphometric measurements on the left side of each specimen of *Patagonotothen sima*.

classified all the subsamples of 20 males and 20 females. Testing the method upon the remaining specimens resulted in 91% correct classification. Thus, the following polynomial should allow *Patagonotothen sima* specimens to be sexed with at least 91% accuracy:

$$F = -4.6350\,(\text{PRAN} - 3.5879) - 2.3490\,(\text{PEC} - 2.7202) + 6.3874\,(\text{D2H} - 2.3260)$$

$$\text{if } F > \bar{x} \Rightarrow \text{Male; if } F < \bar{x} \Rightarrow \text{Female}$$

Applying this polynomial, seven of the nine specimens falling in the overlapping tails of the frequency distributions of D2H/SL proportions were correctly sexed. The remaining two specimens were misclassified by both discriminant methods without obvious reason.

Discussion

No direct observations of the reproductive behaviour of *Patagonotothen sima* have been made, but it is expected that it is similar to that of *P. tessellata*, for which nest building and parental care has been described (Rae & Calvo 1995).

Sexual dimorphism is widely known among fishes, but dimorphism in the morphology and relative size of fins, as found here, has not often been noted in literature.

Although the significance of the sexual dimorphism in *P. sima* is unknown, it may be related to the common occurrence of a non-dimorphic closely related species, *P. cornucola*, in the Falkland (Malvinas) Islands (Norman 1937), in Puerto Deseado (Gosztonyi, personal observation), and in Tierra del Fuego (Rae & Calvo 1995). In the last locality, females of both species, markedly distended with eggs, have been observed from July to September, indicating a coincident spawning season. Except for a conspicuous whitish oblique streak on the cheek in *P. cornucola*, both species are of roughly similar size and general appearance. Therefore, the higher second dorsal fin in males of *P. sima* might not only be a means to lure females to the nests, but also accomplish this in a species-specific manner (Andersson 1994). The hypothesis of the higher second dorsal fin in males of *Patagonotothen sima* as a species recognition trait needs to be carefully studied, but it is a conceivable explanation for the sexual dimorphism demonstrated in this species.

Table I. Relative soft-dorsal fin height. Female and male intervals $\bar{x} \pm s\,d$ for the proportion of the soft-dorsal fin height in the standard length (D2H/SL) in *Patagonotothen sima*.

	Males (n = 30)		Females (n = 32)	
	$\bar{x} - s\,d$	$\bar{x} + s\,d$	$\bar{x} - s\,d$	$\bar{x} + s\,d$
D2H/SL	0.1412	0.1643	0.1124	0.1273

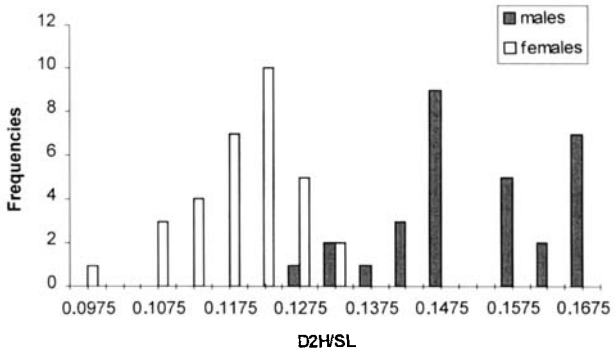

Fig. 2. Frequency distributions of the proportion of the soft-dorsal height in the standard length (D2H/SL) in males (n = 30) and females (n = 32) of *Patagonotothen sima*.

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